TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

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Society of
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Washington, D. C.

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MEETING OF OCTOBER 13, 14, 15, 1919
PITTSBURGH

RESULT OF ANNUAL ELECTION
OCTOBER, 1919

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SOCIETY OF MOTION PICTURE ENGINEERS

Membership in the Society of Motion Picture Engineers stands for unselfish service to the Industry. Application for membership is by invitation and endorsement. All checks should be made payable to the Society of Motion Picture Engineers.

All receipts are expended directly to promote the objects of the Society and the interest of its members. There are no salaries or emoluments of any kind.

The following are extracts from the By-Laws:

The objects of the Society are: The advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein and the maintenance of a high professional standing among its members.

An Active Member is one who is actually engaged in designing, developing or manufacturing materials, mechanisms or processes used in this or allied arts, or who is interested directly in the art.

Any person of good character may be a member in any or all classes to which he is eligible.

Prospective members shall be proposed in writing by at least one member in good standing, and may be elected only by the unanimous vote of the Board of Governors.

All applications for membership or transfers in class shall be made on blank forms provided for the purpose, and shall be accompanied by the required fee.

The entrance fee for all members shall be thirty-five dollars ($35.00). The annual dues shall be fifteen dollars ($15.00), payable in advance before the annual meeting (October of each year). That is, the total fee for the fiscal year, which includes the entrance fees and first annual dues, is $50.00 for all members.

CLASSIFICATION OF PAPERS PRESENTED BEFORE THE SOCIETY UP TO AND INCLUDING THE PITTSBURGH MEETING IN 1919

Cameras, Printing Machines, Camera Equipment, Etc.

Bell—Motion Picture Film Perforation.

Gregory—Motion Picture Cameras.

Gregory and Badgely—Attachments to Professional Cinematographic Cameras.

Carbon Arc Equipment, Etc.

Kunzmann—Carbon Arc for Motion Picture Projection.

Professional Motion Picture Machines

Westcott—Precision: The Dominant Factor in Motion Picture Machines.

Caldwell—Light Intensities for Motion Picture Projection.

Porter and States—Some Considerations in the Application of Tungsten Filament Lamps to Motion Picture Projection.

Roebuck—Sprocket Teeth and Film Perforations and Their Relationship to Better Projection.

Portable Motion Picture Machines

Victor—The Portable Projector; Its Present Status and Needs.

Cook—Advantages in the Use of the New Standard Narrow Width Slow-Burning Film for Portable Projectors.

Motion-Picture Film

Blair—Motion Picture Film in the Making.

Electrical Equipment

Report of the Committee on Electrical Devices—I.

Report of the Committee on Electrical Devices—II.

Incandescent Lamps and Equipment

Dennington—The Projection of Motion Pictures by Means of Incandescent Lamps.

Dennington—Incandescent Lamps for Motion Picture Projection.

Studios and Laboratories

Allison—Standards of Exposure.

Mayer—Artificial Light in the Motion Picture Studio.

Allison—Standardization of Motion Picture Industry in the Ideal Studio.

Mott—White Light for Motion Picture Photography.

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Architectural Subjects

Smith—Off-set Projection.

Jenkins—The Motion Picture Projection Room.

Richardson—The Projection Room and Its Requirements.

Optical Research

Jenkins: Condensers: Their Contour, Size, Location and Support.

Report of Committee on Optics

Corey—Optical Requirements of Motion Picture Projection Objectives.

Jenkins—Condensers.

Kellner—Function of the Condenser and the Projection Apparatus.

Richardson—Some Phases of the Optical Systems of the Projector.

Gage—Condenser Design and Screen Illumination.

Story—Preliminary Measurements of Illumination in Motion Picture Projection.

Colored Photography

Kelly—Natural Color Cinematography.

Kelly—Adding Color to Motion.

Miscellaneous

Richardson—Theory vs. Practice as Applied to Standardization and Some of the Things to be Considered as Proper Subjects for Standardization.

Burrows—Fundamentals of Illumination in Motion Picture Projection.

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Richardson, F. H. Moving Picture World, 516 Fifth Ave., New York City.

Robin, J. E. 729 Seventh Ave., New York City.

PRESIDENT'S ADDRESS

The Society of Motion Picture Engineers is now a well-established organization. During the three years of its existence, notwithstanding the hard struggle which we have experienced during an exceedingly trying period, we have, at all times shown the spirit of progress which has resulted in a successful organization. The success with which we have met has not been due to individual efforts, but rather to the united efforts of our members.

I had hoped to be able to present some statistics of the Motion Picture Industry, in order that I could more strongly impress upon you the magnitude of the industry which your considerations and standardizations will ultimately affect. While no exact figures are available on films now produced in the United States, an estimate has been made that the production exceeds 1,000,000,000 feet, with a valuation of approximately $40,000,000.00, of which three-quarters covers photoplays, the other one-quarter being divided among travelogue, news service, comedy and industrial films. These figures cover only the films produced and do not cover the investment in studios, laboratories, factories, exchanges or theatres. Were we able to get an approximate financial estimate involving the Motion Picture Industry as a whole, we would be able to more thoroughly realize the burden we are called upon to assume.

The Society is the technical clearing house of the Motion Picture Industry. Our membership is composed of men who are each and every one expert in his own line and, because of this, we meet periodically for the purpose of discussing the various problems peculiar to the industry.

Motion pictures have rightfully been called the universal language. In the past, their use has been confined largely to entertainment, but at the present time there is a healthy natural tendency towards their use for educational and research purposes.

In view of the work which we are called upon to do, I do not believe that our Society is receiving the proper recognition from the industry. Just how this recognition can be acquired and what form it should take, I shall not now even venture specific suggestions, but I do realize that we should be in closer relationship with the leaders of the industry who mainly are responsible for its advancement because we are all aiming towards the same objective—that of producing better pictures by the most effective methods.

I again wish to impress upon you that our Committees are not sufficiently active. There does not seem to be sufficient co-operation and exchange of ideas. To take care of this situation, beginning with this meeting, we are going to set aside a definite period during our sessions when the chairman of each committee can get together with the members of his committee to prepare a report for presentation to the Society. This is indicated in the program of the meeting, copies of which you have, and to further assist, a list of the personnel of the various committees will be posted in the rear of this room.

One of the subjects which should receive our most serious consideration is that of the presentation of papers. I shall not anticipate nor supplement the report of the Committee on Papers, however I do feel that all of the Society should be sufficiently informed on some subject to individually present a paper on some phase of the industry. In the past, most of the papers have been prepared and presented by a few faithful members, while the rest of the members are content to sit back and listen to the presentation and discussion and thereby benefit by the experience of others without contributing anything themselves. Consequently, the work of the Committee on Papers has been decidedly difficult and this is a condition which should be corrected without delay. This committee should be in a position to select what papers should be presented, instead of having to write letters of request for members to prepare papers. Furthermore, I believe that the papers should originate through the various standing committees, which, when they meet, should decide on what subjects should be covered by a paper and then certain members of that committee should be designated to prepare the papers. When this information is placed in the hands of the Committee on Papers it can very easily line up the schedule long before the time of the meeting. The manuscript can then be submitted and advance copies can be printed and sent to the chairmen of the various committees who can designate certain members to discuss the paper. In this way, we shall obtain the maximum result. To assist those who are preparing papers, the Committee on Papers has prepared a little booklet for their guidance.

I also wish to touch on the work of our Committee on Publications. Our semi-annual proceedings are now being distributed promptly and because of the publicity of the two leading trade magazines, we are receiving a large number of orders for single copies. We have a good supply of all copies of the proceedings except Vol. I, and we have been offering these, unbound, for $1.75 per set to projectionists, with good results. Our first bound volume is now being distributed, the price being $1.50 to members, to cover the cost of binding, and $5.00 to non-members. About half of our membership have ordered copies and I wish the others would place their orders immediately with Mr. Smith, Mr. Jenkins or the writer. There are only about 40 copies still available. The value of this volume is inestimable because there is absolutely no other book which contains such a fund of technical information of the Motion Picture Industry.

After talking with several members of the Society I believe it is the general opinion that some consideration should be given by the Society relative to increasing the initiation fees and membership dues. I feel also that the price which we charge for our transactions is too small, as it is not even sufficient to cover the cost of publication. I trust that this matter will receive your serious consideration during this session.

The foregoing embodies about all that I feel it is necessary to say but as a last word in concluding, I desire to leave with you one thought more vital than all others; namely, that not only does the success of this Society, as a whole, depend upon the collective activities of its members but also that each member, to acquire the highest benefit for himself and others, should take an active part in this collective effort. From all sides, I have met with most cordial encouragements and assistance from those who have given of their time, without any recompense and for this I thank you most cordially. The meeting is now yours.

PRELIMINARY MEASUREMENTS OF ILLUMINATION IN MOTION PICTURE PROJECTION

By W. E. Story, Jr.

First efforts to compare accurately the total illumination in motion picture projection with different optical arrangements, led to such improbable conclusions as to point to errors of observation so large as to render the required comparison unsatisfactory. The problem is to compare the quantities of light falling on the objective lens through a standard motion-picture aperture, with different sizes of source and objective; with different condenser systems, and with different distances between the various components. The reason for considering the light falling on the objective rather than on the screen is that the efficiency of the objective depends on its design, and with the large number of designs now at hand, the addition of this complication seemed inadvisable—especially as this problem belongs to the lens designer alone, and has nothing to do with the relation of the different parts of the projection apparatus. Accordingly, for the objective lens there was substituted a dummy objective, that is, a circular hole in a brass plate, this hole being of the size of the assumed effective diameter of the lens and the plate being at a distance from the aperture equal to the assumed focal length of the lens. Immediately behind this dummy objective was put a piece of flashed opal glass considerably larger than it, and 4 inches from this glass another similar one—a connecting brass tube blocking out stray light between. The illumination of the center of this second opal glass by the first is very even, and is proportional to the total light flux delivered by the rest of the optical system to the objective. The even illumination of this second opal glass was measured by a photometer mounted directly behind it, and built in as one assembly with the opal glasses, the dummy objective, and the aperture plate. The aperture plate was 5½ inches in front of the dummy objective; the 5½ inches corresponding to the focal length of an objective frequently met in practice. An arrangement was made for changing the size of the objective opening.

The above assembly was mounted on the rider of an optical bench—another rider carried the condenser, and a third, the source and its housing. To obtain a source of uniform brilliancy and variable size an opal glass was strongly lighted from behind. Two thin metal shutters slid across the front of this opal glass in such a way that an illuminated square of any desired size and with two of its sides vertical served as the light source. The shutters lay close to the opal glass to give the same source for all points of the condenser.

The method of procedure was as follows:

The illumination of the opal glass source was carefully kept constant at all times. With a given source side, source-condenser distance (which for convenience we shall call d_1) and objective,

the distance from condenser to aperture plate (d_2) was varied inch by inch, and the corresponding photometer readings taken—two readings being taken at each position. In this way curves were obtained for a large number of different conditions. Sample curves are shown in Figs. 1, 2, 3, 4.

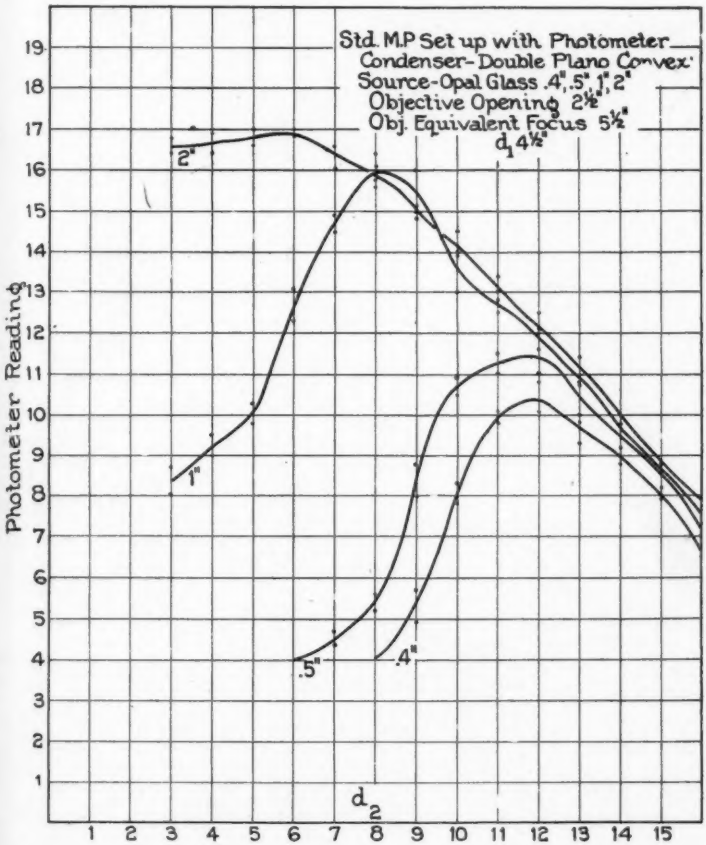

Std. M.P Set up with Photometer
Condenser-Double Plano Convex
Source-Opal Glass .4", .5", 1", 2"
Objective Opening 2½"
Obj. Equivalent Focus 5½"
d_1 4½"
2"
1"
.5"
.4"
Photometer Reading
d_2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

FIG. 1

The crossing of the curves in (1), (2) and (4) could be explained only by some error in observation. Check curves at different times did not give the same results. The most probable source of error was the photometer. Accordingly, it was decided to try a photoelectric cell as a means of measuring the total light flux.

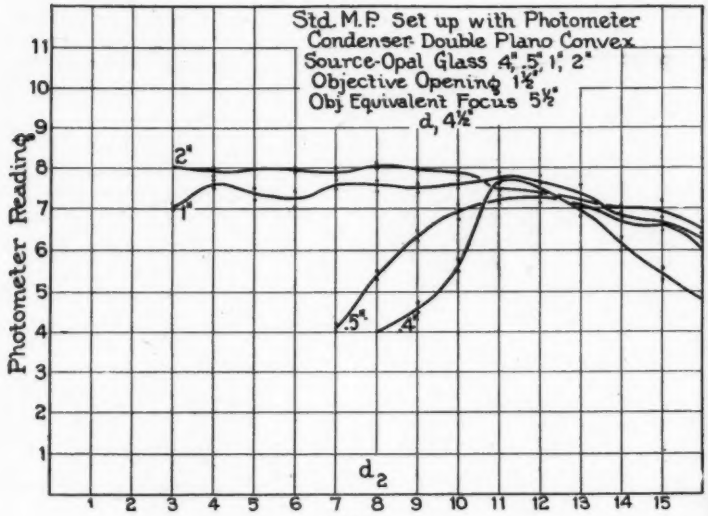

Std. M.P. Set up with Photometer
Condenser Double Plano Convex
Source-Opal Glass 4", .5", 1", 2"
Objective Opening 1½"
Obj Equivalent Focus 5½"
d, 4½"
Photometer Reading
d2
2"
1"
.5"
.4"

FIG. 2

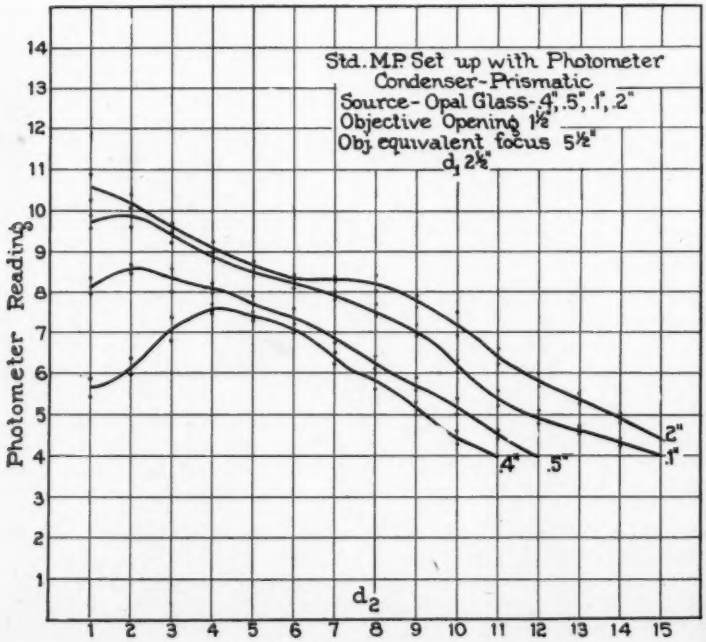

Std. M.P. Set up with Photometer
Condenser-Prismatic
Source-Opal Glass-4", .5", 1", 2"
Objective Opening 1½"
Obj equivalent focus 5½"
d1 2½"
Photometer Reading
d2
2"
1"
.4"
.5"

FIG. 3

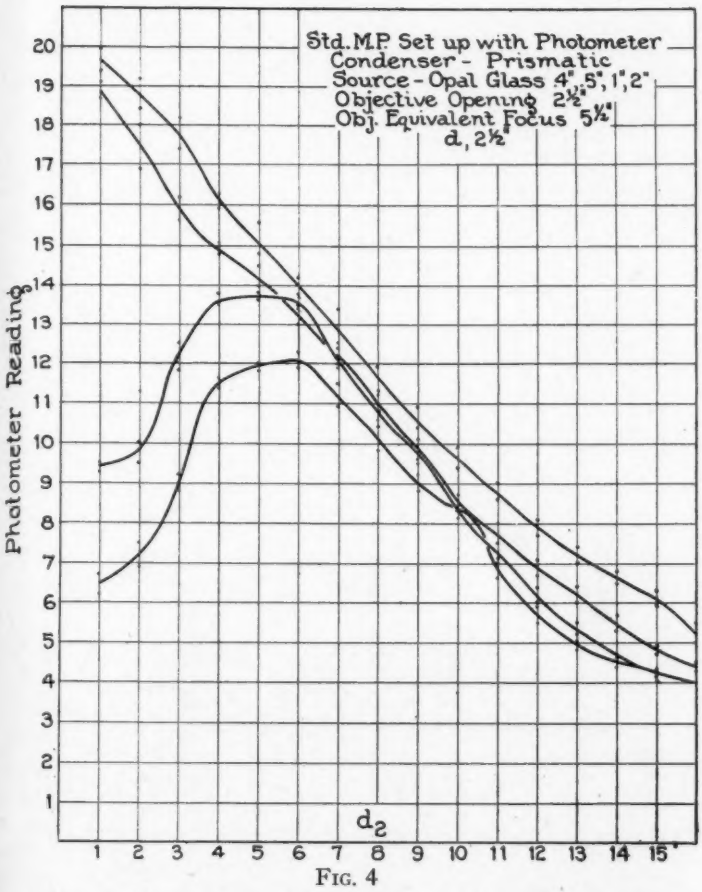


FIG. 4

The potassium photoelectric cell at hand was not sufficiently sensitive to be used in connection with all the opal glasses used with the photometer. Accordingly, an incandescent filament was substituted for the variable source. This filament consisted of four similar helices side by side, each of .089 inches diameter, and .48 inches long, and the spaces were .038 inches wide. This gives a uniform source .48 inches high by .47 inches broad. The increase of light obtained by this means was still not sufficient to permit of the use of the photoelectric cell. The second opal glass beyond the objective was next removed, and the cell put in its place, being so arranged that as much of the potassium surface as possible could view the whole aperture opening. A suitable deflection was now obtained with the galvanometer.

In series with this cell there was a constant potential of 72½ volts, and a reflecting galvanometer of a sensitivity of 3.98 x 10^{-9} amps. In place of the customary scale, a narrow horizontal slit was cut in a box in which a photographic plate moved up and down directly behind the slit. This motion was regulated by a cable and pulleys to be one-half the horizontal motion of the aperture-objective assembly. As d_2 is changed then, the light reflected in the galvanometer mirror will trace out a curve on the plate, the abscissae of which curve, if the zero point is correctly chosen, are one-half the distance d_2, and the ordinates the galvanometer deflection.

The first plates made were run both ways on each setting, giving a double curve. It was found, however, that under normal conditions, these two curves checked within 2 per cent. As this is about the limit of difference detectable with the eye, it was considered sufficient to run but a single curve for each arrangement. Accordingly, a number of curves of different arrangements were run on the same plate for comparison, running the plate up and down (that is, increasing and decreasing d_2 alternately for each successive curve), and making the change of arrangement at the end of each curve. At the beginning of each curve the reading of the galvanometer was photographed with an opaque slide in front of the aperture and through these marks the zero line of the light flux was drawn. During the progress of the first curve

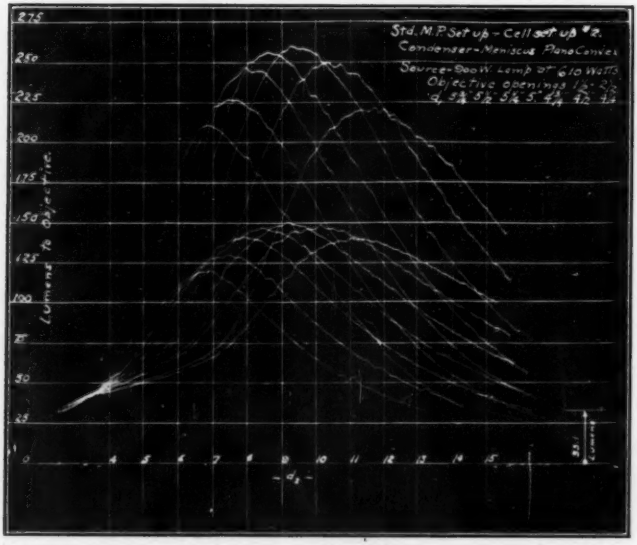

Std. M.P. Set up - Cell set up "2."
Condenser - Meniscus Plano Convex
Source - 500 W. Lamp at 6.10 Watts
Objective openings
Lumens per objective
$-d_2-$

FIG. 5

run on each plate an open lamp in front of the plate slit was flashed as the aperture plate crossed each inch mark, thus marking the d_2 scale photographically.

A sample plate is shown in Fig. 5.

The seven higher curves are with a 2½ inch objective and source-condenser distances d_1 decreasing by ¼ inch steps from 5¾ inches as the abscissae of the maxima increase. The lower curves are with a 1½ inch objective and the same d_1's as the other group.

These curves of course indicate the sharpness of setting necessary for d_2 in order to get within any given proportion of the maximum light available for this particular value of d_1.

The loci of the maxima for the two objectives are given in Fig. 6.

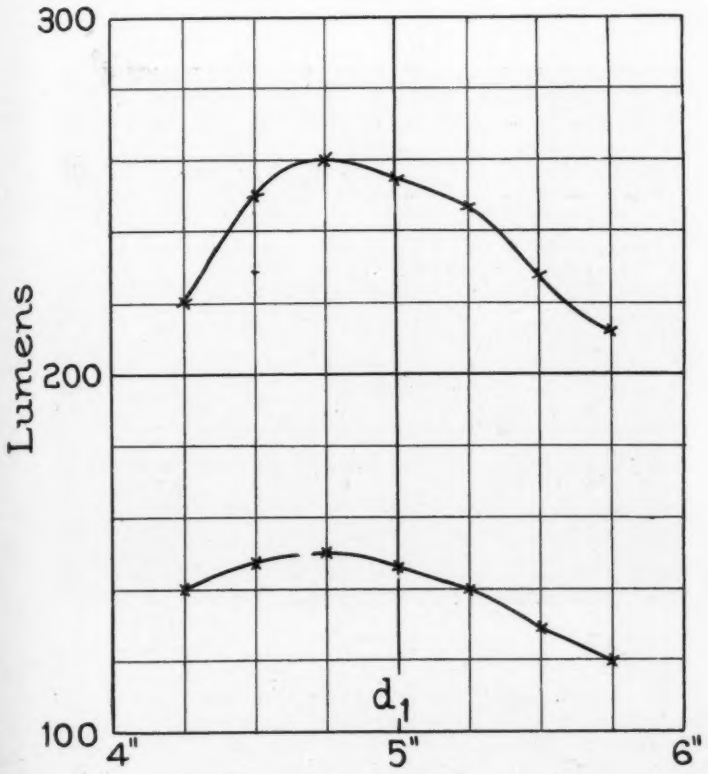


FIG. 6

The abscissae are the values of d_1 for the curves of Fig. 5 and the ordinates are the deflections of the corresponding maxima. These two curves indicate the sharpness of setting of d_1 necessary for any required approach to the maximum light obtainable. Latitude of position of the different parts is of course very desirable for any arrangement and may be the deciding factor in the choice of lenses.

To determine whether the galvanometer deflection was proportional to the quantity of light passing the objective, curves were made without condenser or aperture, and the abscissae representing the distance from the source to the objective. When this distance is large, the amount of light falling on the opal glass is of course inversely proportional to the square of this distance. Also for large distances the amount of light passing objectives of different sizes, will be proportional to the area of their openings.

Fig. 7 shows curves made with a 2½ inch and 1¾ inch dummy objective.

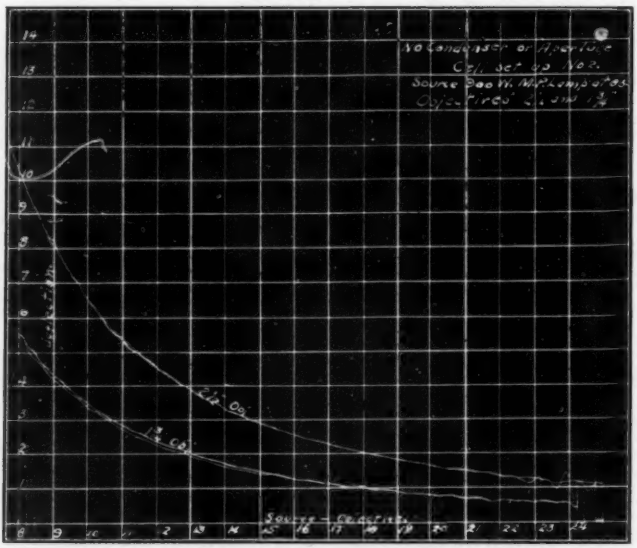


FIG. 7

In the table below (Fig. 8) column I indicates the distances of the dummy objective from the source. Columns II and III give the product of light received on the 1¾ inch and 2½ inch objectives by the square of the distance of the objectives from the source, and column IV gives the ratio of the light passed by the two lenses at any given distance.

Dist. 2 I d	d^2 x defl. II 1¾ Obj.	d^2 x defl. III 2½ Obj.	IV* III/II
8	176	328	1.86
9	173	324	1.87
10	173	326	1.87
11	170	327	1.92
12	167	327	1.95
13	169	330	1.95
14	165	328	1.98
15	165	327	1.98
16	164	328	2.00
17	167	334	2.00
18	167	329	1.96
19	163	332	2.06
20	156	331	2.12
21	152	337	2.28
22	151	324	2.14
23	156	331	2.18
24	162	337	1.94
	163	324	
		331	
		315	

*With a new cell especially designed for this work, it is hoped values in column IV more nearly 2.04 will be obtained.

The constancy of the values in columns II and III shows the deflection to be proportional to the light through an objective of a given size, and the agreement of the values in column IV with 2.04, the ratio of the objective areas, shows the deflection to be almost independent of the size of the objective as long as the total quantity of light transmitted is the same. Columns II and III are plotted in Fig. 9.

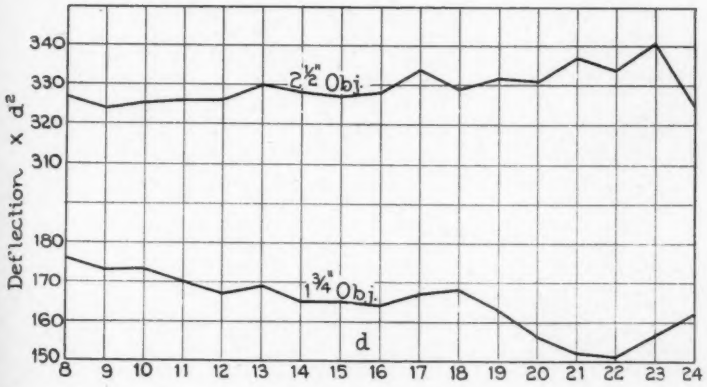


FIG. 9

Those deflections in the low end of the curves are so strongly affected by inaccuracies of the zero line as to be very doubtful. This inaccuracy probably also accounts for the gradual decrease in the curve of the 1¾ inch objective. Large deflections, those in which we are most interested, will, of course, be influenced but little by these variations of the zero.

A slight change in the sensitivity of the present photoelectric cell was noticed from one day to another. To make allowance for this before each plate was made, a standard lamp was set at such a constant distance from the aperture that all the light passing through it passed through the objective as well, and then the deflection due to this known amount of light, photographed. From these marks the scale of the ordinates denoting lumens was calculated. Due to differences of absorption and source temperature, this scale of course must not be regarded as accurate, but merely as an approximation.

An incandescent filament was photometered at different efficiencies, and the maximum horizontal candle power plotted against the watts consumed. This same filament was lighted at a convenient distance in front of the dummy objective, and the deflection-watts curve plotted.

Fig. 10 shows these two curves—the ordinates of the second

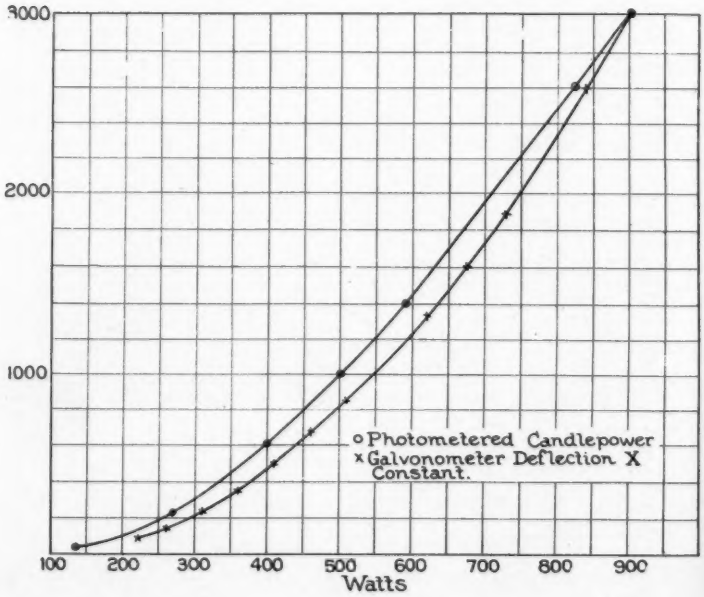


FIG. 10

being multiplied by such a constant as will make the 900 watt points of the two curves coincide.

As might be expected, these two curves cannot be made to coincide by any choice of scales, since the maximum energy is in the shorter wave-lengths the higher the brilliancy, and the eye has its maximum sensitivity in the yellow, while the photoelectric cell is most sensitive in the blue end of the spectrum. Since in motion picture projection the eye is the judge of brilliancy lights of different colors cannot be accurately compared by the cell method. The curves for any given condenser and source brilliancy are comparable, but when curves made with different sources or absorbing media in the system, are in question, corresponding points in the two set-ups must be compared by means of a photometer. If the readings of one set-up be then multiplied by the factor thus obtained, the curves will be directly comparable. At present we are using a photometer as a final judge between different systems, but for determining the most advantageous arrangement for any particular system the photoelectric cell seems to offer a far quicker and more accurate method.

Of course, the method of measuring the light delivered by an optical system says nothing about the distribution on the screen. This will have to be determined separately, and probably cannot be determined by any method that does not depend on direct observation by the eye. The method described above is to be applied only after the general limits, through which the optical arrangement may be varied without causing too uneven a distribution on the screen, have been determined.

In a following paper we hope to give some comparisons of different optical systems in common use, as well as those giving the most light at present obtainable.

SELECTION OF PROPER POWER EQUIPMENT FOR THE MODERN MOTION PICTURE STUDIOS

By H. F. O'Brien and H. A. Campe

Synopsis: This paper cites most of the factors that must be considered in making the proper selection of power equipment for the Motion Picture Studios. After reviewing the more important factors, suggestions are made regarding the type of equipment that should be selected to produce the best possible results under given conditions.

OUTLINE

I. Introduction.
II. Two-wire versus three-wire distribution.
III. Classification of apparatus.
Description—Discussion—Criticism.
1. Rotary converter.
1a—Two-wire.
1b—Three-wire.
2. Motor-generator set.
2a—Two-wire—two unit.
2b—Three-wire
Three-wire generators.
Two-wire generators—Balance set.
Two—Two-wire generators.
IV. Conclusions.

INTRODUCTION

The new studios have decided from either their own experience or that of others, that it is an economical proposition for them to have their studios so equipped that a sufficient supply of electrical energy will be available for the proper illumination of their stages. During the past two years, there has been a general tendency towards using more artificial illumination in the studio, almost to the total exclusion of sun light. During this period, there has also been a great tendency to unify the electrical installations so the same nature of current is used throughout, irrespective of the nature of supply current. Some studios, particularly the new ones, in and about New York are being equipped with direct current exclusively.

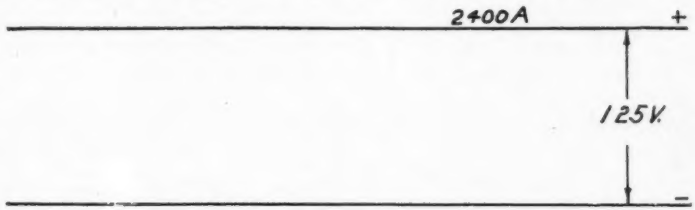
The large power companies, except in restricted zones, are making the extensions of their power distribution system, alternating current, and in fact, have replaced most of their old direct current distribution systems with alternating current. These tendencies have forced most all of the studios to install their own substations for converting the alternating current supply to direct current.

Except in certain portions of New York City, there are very few studios located where they can obtain sufficient direct current to meet their requirements, but nearly every studio is located where

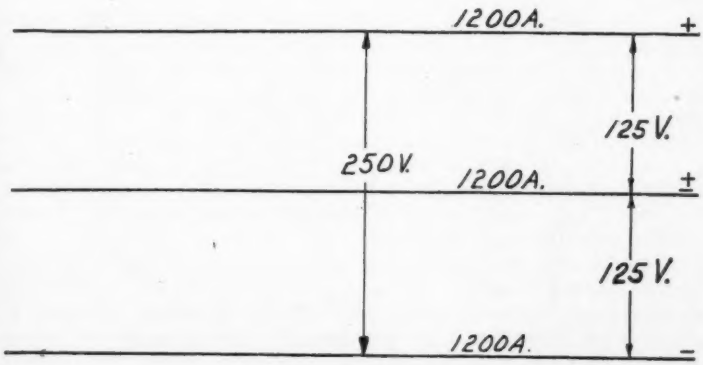
alternating current can be purchased in sufficient quantity so that the easiest and most economical means of obtaining direct current is to purchase alternating current power and convert it. Converting apparatus will be described later in this paper.

II. TWO-WIRE VS. THREE-WIRE DISTRIBUTION

A two-wire system is one in which a single voltage is generated and a three-wire system is one in which two separate single equal voltages are transmitted which may be additively combined to produce a third voltage. With the two-wire system, as the name implies, only two wires are required. With the three-wire system, three wires are required for main distribution. On a three-wire distribution system, one wire known as the "neutral" is common to both the equal voltage circuits and carries only the unbalanced current in the system. By unbalance is meant the difference in amperes flowing in the two equal voltage circuits. The other two wires, known as the outside wires, carry their proportional part of the total current in the system, whether balanced or unbalanced.



2 Wire D.C. System.



3 Wire D. C. System.

As a general rule, and particularly where heavy currents at low voltages must be handled, it is desirable from a standpoint of copper economy to install the three-wire distribution system. Most studio electricians have found that the three-wire system has many advantages. For example, a two-wire system handling 300 KW., at 125 volts, would require that each side of the line be of sufficient capacity to carry 2400 amperes. This would call for 4,000,000 CM. of copper for each side, or 8,000,000 CM. of copper per circuit. Such an installation would require very large conduit and would be very difficult to install.

If the same load were to be handled on a three-wire system, each conductor would be required to handle 1200 amperes which would call for 2,000,000 CM. in copper and as most code regulations demand that the neutral or third wire be the same size as the two outside wires, it would take three conductors, of 2,000,000 CM. each. Thus, in this case, 6,000,000 CM. of copper are required for three-wire distribution where it is found that 8,000,000 CM. of copper would be required to handle the same load on a two-wire system.

It is evident, from the above example, that a 25 per cent. saving in copper would be effected by using a three-wire instead of a two-wire system. This saving would be somewhat further increased because of lower installation costs. There is only one argument against the use of a three-wire system and that is the proposition of unbalancing the system. This subject will be discussed under Classification of Apparatus.

III. CLASSIFICATION OF APPARATUS

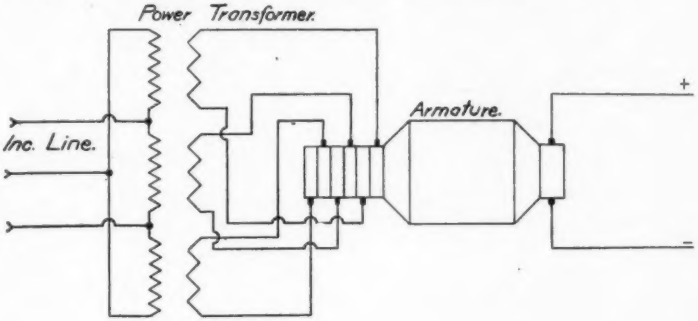
The characteristics of the incoming power supply with respect to voltage and frequency regulation will determine largely the type of equipment to be used. It would be difficult here to make suggestions that would satisfactorily cover each and every installation but the suggestions given later in this paper should, at least, act as a good guide.

In the case of selecting additional apparatus for the studio it is wise to consider equipment similar in characteristics to the apparatus already installed, as undoubtedly, parallel operation of units will be desired. In other words, it would not be good engineering practice to parallel rotary converters with motor-generator sets unless such a scheme would be recommended by a reputable engineer who, after making a careful study of the conditions, would guarantee satisfactory operation.

There are only two practical means of converting alternating current to direct current in the capacity required in the studio; namely, rotary converters and motor-generator sets. We will first consider some of the inherent characteristics of each, for these characteristics determine which type of apparatus will best be suited for the installation.

1. Rotary Converters. The rotary converter is a single-unit machine which received its power from the incoming alter-

nating current line and furnishes direct current at the desired voltage. Power is supplied to the rotary through a bank of transformers having primary or high-tension windings designed for the voltage of the power circuit. The low tension or secondary windings are designed, in the case of a three-phase rotary, to give a voltage of .62 times the direct current voltage desired. In the case of a six-phase diametrically connected rotary, this ratio is .72.

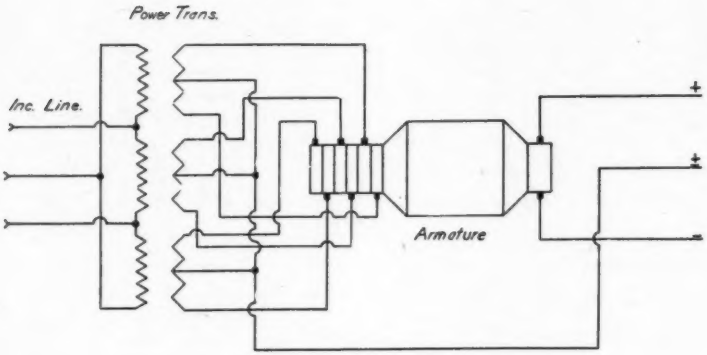


2 WIRE SYNCHRONOUS CONVERTER.
2 WIRE SYSTEM.

1a. Two-Wire Rotaries. While the rotary may be considered ideal, it can only be recommended for studio's application under ideal conditions and these should be very carefully investigated both for present and future possibilities. Inasmuch as the direct-current voltage of a rotary varies in direct proportion to the change of either the voltage or frequency of the circuit supply, the rotary should only be selected for use on a power line having ideal voltage and frequency regulation, since constant direct-current voltage is essential for correct studio illumination. Graphic charts should be taken covering a period of at least two weeks to definitely determine whether or not the conditions of the power circuit will permit this application. The variation in either voltage or frequency should not exceed 3 per cent.

1b. Three-Wire Rotaries. If it is desired to obtain a three-wire direct-current system using a rotary this can be accomplished by bringing out the neutral point of the transformers which would be interconnected star. The maximum balance that is allowable under such conditions is 25 per cent. of full load current.

Either two or three-wire rotaries can be paralleled on the same bus without difficulty. It is understood, of course, that each rotary requires its own bank of transformers for the alternating-current end and therefore the cost of the complete installation will closely approximate the cost of a motor-generator installation.



3 WIRE SYNCHRONOUS CONVERTER
3 WIRE SYSTEM

The new Thomas Ince Studios at Culver City, California, are securing excellent results from their 250 KW. three-wire rotary installation. In the case of this installation, constant voltage on the 2200-volt power circuit is obtained by means of an induction regulator installed in the sub-station of the Southern California Edison Company.

2. MOTOR-GENERATOR SETS. Motor-generator sets are built in several combinations with respect to the driving motor. The only type we need to consider for studio applications are those driven with alternating-current motors. In this classification we will consider sets driven by squirrel cage induction and synchronous motors.

As induction motors have generally been used, we will consider the characteristics of this type first. The induction motor has what is commonly known as "Slip." By this we mean that the motor will slow down slightly with an increase of load. As the generator is directly connected to the motor, it will correspondingly decrease in speed, resulting in a slight drooping characteristic in the generator or direct-current voltage. The speed of an induction motor is practically constant under constant load conditions, from 80 per cent. normal voltage to slight over-voltage. This characteristic is a point in its favor where a studio is located where there is slight voltage fluctuations on the incoming power line. Induction motors only should be considered in the smaller sizes ranging up to 100 KW. capacity, except in special cases. The power factor of the squirrel cage induction motor will vary from about 74 per cent. at one-quarter load to about 92 per cent. at full load. These motors are always started with auto transformers in the starting circuit so that the starting current is not excessive. Normally, the starting

current will run from 1.3 to 1.5 times full load current which should not be objectionable to the power companies.

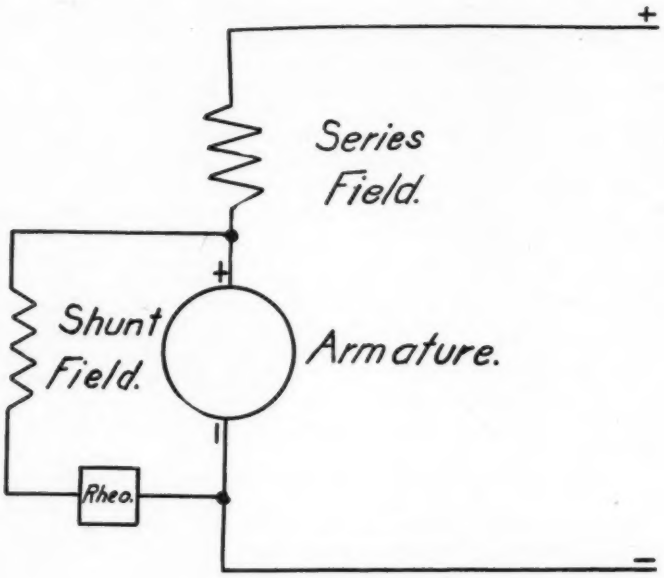
Modern synchronous motors have a squirrel cage or damper winding in the rotating element, so that they have practically all the good starting characteristics of an induction motor. In addition, they can be wound to operate at unity power factor at light loads. The speed of a synchronous motor depends only upon the frequency of the power circuit and is not affected by load variation. As most of the large power companies keep the frequency within a 3 per cent. variation, it can readily be seen that a synchronous motor would be very desirable inasmuch as it operates at constant speed, resulting in constant voltage at the generator terminals. Some electricians imagine that a synchronous motor is a piece of apparatus requiring expert attention and care. Possibly they may have had some unpleasant experiences with the older obsolete types, but the modern synchronous motor is as simple to handle as an induction motor. It starts as an induction motor and comes up to synchronous speed readily so that it can be connected to the line without difficulty.

Let us next consider the different types of direct-current generators and their characteristics. There are two general types of generators; namely, shunt-wound and compound-wound. The shunt-wound generator gives a variable voltage characteristic under variable load conditions, whereas, the compound-wound generator, when properly adjusted, will give a constant voltage characteristic over a wide variation in load. Obviously, we will consider only the compound-wound generator for studio service.

2a. Two-Wire Generators. The simplest form of a generator is a single-unit two-wire type, in which a single voltage only is generated. The voltage produced by this type of generator can be varied within a limited range by means of the shunt field rheostat.

2b. Three-Wire Equipments. There are three practical means which may be employed through the use of motor-generator sets to produce direct-current supply for three-wire systems; namely, three-wire generators, two-wire generators with balancer set, and 2 two-wire generators of equal voltage permanently connected in series. A short description of each will follow.

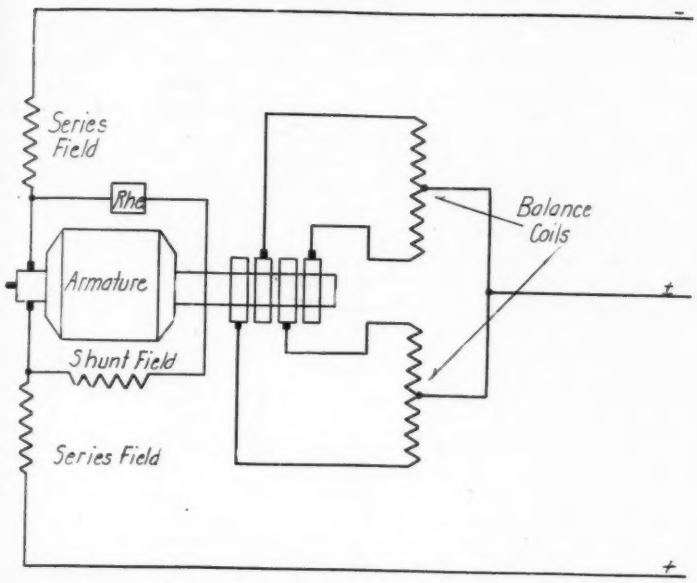
Three-Wire Generators. The single unit three-wire generator is simply a modification of the two-wire generator in which certain internal connections, together with balanced coils mounted externally or internally, produce a neutral point, which, with the main generator terminals, gives a double voltage or a three-wire system. The commercial three-wire generator is built to take care of from 10 to 20 per cent. unbalanced condition, which means that one side of the three-wire system may be loaded 10 to 20 per cent. more than the other side without involving difficulties. In studios where the load is being constantly shifted as the lamps are plugged in on various circuits, it is practically impossible to keep the unbalance within the limits required by three-wire generator design, due



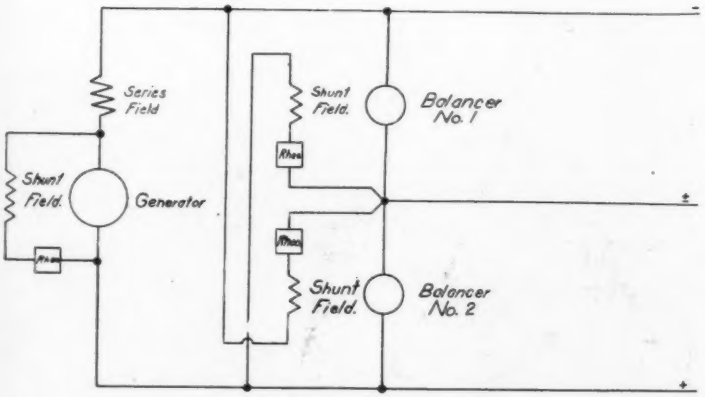
2 WIRE D.C. GENERATOR.
2 WIRE SYSTEM.

to the rapidly varying conditions which must be met by the studio electrician. In view of the foregoing statements, the ordinary commercial type of three-wire generator is not suitable for studio application where the unbalanced condition will often run as high as 30 to 40 per cent. While some may argue that such a condition is unwarranted and could be prevented by proper care in plugging in the lamps to maintain a better balanced condition of load, we must remember that time is a most valuable asset in film productions.

Two-Wire Generators with Balancer Set. In larger installations, using a three-wire system, it is practical to employ a two-wire generator of double the required voltage and produce the neutral or third wire by means of a balancer set. This balancer set consists of two compound-wound generators direct connected on the same shaft and mounted on a common base, mechanically.



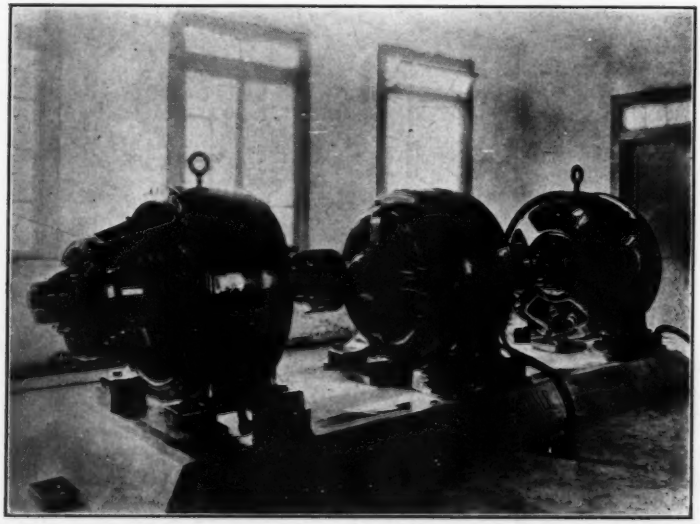
3 Wire Gen. 3 Wire System



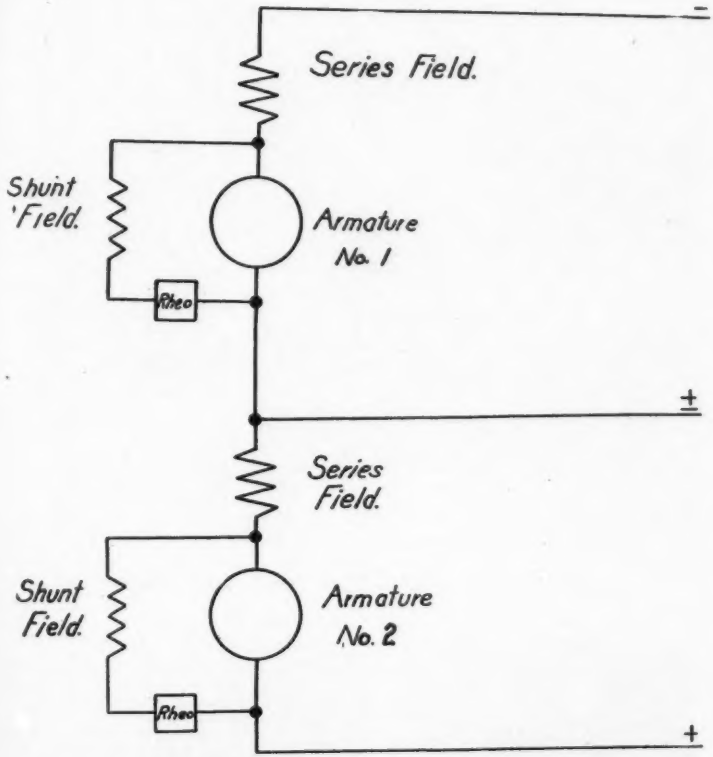
2 WIRE GENERATOR WITH BALANCE SET.
3 WIRE SYSTEM.

Electrically, they are interconnected across the leads of the two-wire machine and the electrical connection between the two units of the balancer set form the neutral or third wire. When one side of the system becomes loaded more than the other side, the fields of these two machines are interconnected in such a manner that the generator on the side with the lightest load becomes a motor and drives the other generator as a booster. In the event that both sides of the system are balanced both units of the balancer "float" on the line. The unbalance is limited to the capacity of the balancer unit used.

TWO TWO-WIRE MACHINES CONNECTED PERMANENTLY IN SERIES. The three-unit motor-generator set, as the name implies, consists of one motor direct-connected to two generators, one on either side, all being mounted on a common base. The generators are permanently connected in series. The neutral is brought out from the connection between the two generators. It can readily be seen that with such combination, each generator can be loaded to its capacity, independent of the other, thereby giving the set a maximum unbalance up to 50 per cent. of its capacity. There are two other excellent advantages of this type over a straight three-wire generator. First, for any direct-current generator, for the basis of electrical comparison, it is a fundamental of design that the product of the KW. and the revolutions per minute is a constant. It is therefore evident that if instead of one large single generator,



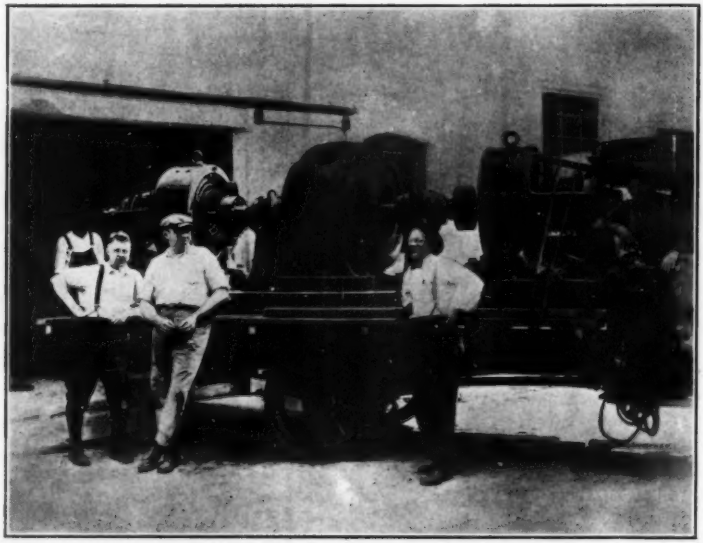
120 K.W.-three unit set in Brunton Studios, Los Angeles, Cal.



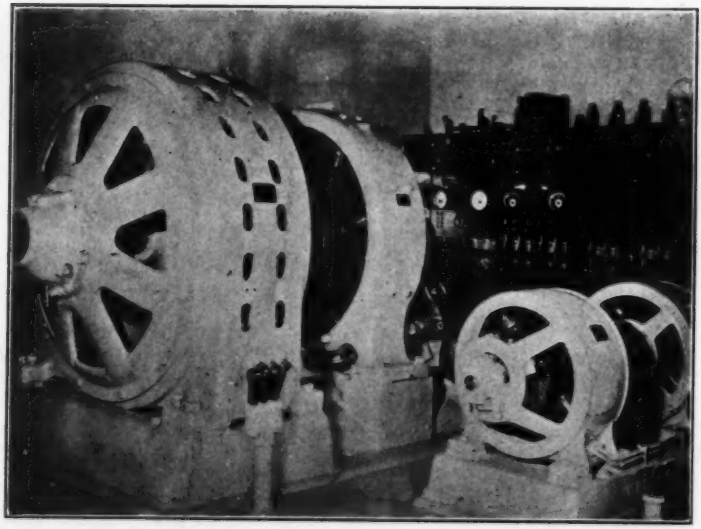
2 - TWO WIRE GENERATORS. IN SERIES. 3 WIRE SYSTEM.

we could use two generators each of half the capacity that we could double our speed and still obtain about the same results as far as electrical performance and maintenance are concerned. The cost of the higher speed set is less than the cost of the lower speed set of the same capacity. Second, paralleling two two-wire machines operating as a three-wire system is less complicated than paralleling three-wire rotaries or three-wire generators.

Realizing that the question of unbalanced load also affects the voltage regulation and that it is absolutely essential to the studios to secure good voltage regulation regardless of what their unbalance would be, after consulting with electricians of several of the larger



150 K.W.-three unit set, Clunes Studios, Los Angeles



300 K.W.-two unit motor generator set with balancer, Metro Studio, Los Angeles

studios in the West, the use of a three-unit set was recommended as a solution of this problem. That this recommendation has worked out to good advantage, is without question. The first three-unit set tried out was installed at the Robert Brunton Studios in Los Angeles, California, and this set has now been in operation for more than two years and has given perfect satisfaction. Since then, additions have been made until their capacity is now 460 K.W., all in three-unit sets, on which they have standardized.

IV. CONCLUSIONS

Therefore, after a careful consideration of the many features that have been brought out, the conclusion is reached that the two types of apparatus best suited for converting alternating-current supply for direct current for studio illumination, are the rotary converter and the three-unit motor-generator sets for three-wire systems. The two-unit two-wire motor-generator sets might be best suited for small installations but it would certainly be third choice on larger installations.

Furthermore, we would especially call your attention to the fact that while the selection of proper equipment for supplying direct-current to the studio is of great importance, it is by no means the only problem which will have to be solved. The selection of proper switchboard for controlling and paralleling the generators and providing for the proper selection and protection of stage feeder circuits must be given careful consideration. Power transformers, where used must be of ample capacity and of the most suitable voltages. Proper protective devices must be installed to insure continuity of service and protection to human life.

Care should be used in placing apparatus in the power-house of the studio so as to keep to a minimum, the amount of floor space required and yet make all parts easily accessible for times of unforeseen emergency.

In laying out a new studio it would be well to make provisions for future extension. Failure to do this has already proven somewhat expensive to some of our large studios.

There are many other factors which should wisely be considered in making a complete electrical layout for the studio but we have discussed with you what we consider to be the most important and which must be settled before other details can be decided upon.

THE CONTINUOUS REDUCTION PRINTER

By ALEXANDER F. VICTOR

Following the introduction and adoption of the Safety Standard film, the next logical step of progression was the creation of a supply of this film, adequate to the needs of the field it is to safeguard.

The most immediate and richest source of film subjects would naturally be the thousands of standard negatives already in existence.

Only one bit of apparatus was required to bring this treasure-trove into the immediate service of the home, school and church. A satisfactory reduction printer was the essential thing.

The existing reduction printers, while producing results of excellent quality, lacked the speed for quantity production, which is certain to be required in the enlarged field of Safety Standard Film.

Most of you are familiar with the step reduction printer, whereby the negative and positive film are moved step by step—the movements of the two being perfectly synchronized. The two films are some distance apart—a lens interpolated, and a light source back of the negative. A shutter masks the light exposure during the movement of the film. Owing to the reversing action of the lens, the two film strips must move in opposite direction. With the most accurate workmanship, it is impossible to operate two intermittent movements at a high rate of speed, without causing a certain amount of vibration. Obviously the step reduction process must be less speedy than a continuous method of printing.

So my ambition reached out toward the creation of a Continuous Reduction Printer. To realize this desire, all that appeared necessary would be to move the two film strips in opposite directions at an absolutely constant but dissimilar speed. Thereby the intermittent movement and the shutter would be eliminated.

Complicating my work was the fact that the two film strips are located at least ten inches apart, and would involve not less than three flawless gears. Gears so perfect that a combined error of a thousandth of an inch would render the scheme worthless.

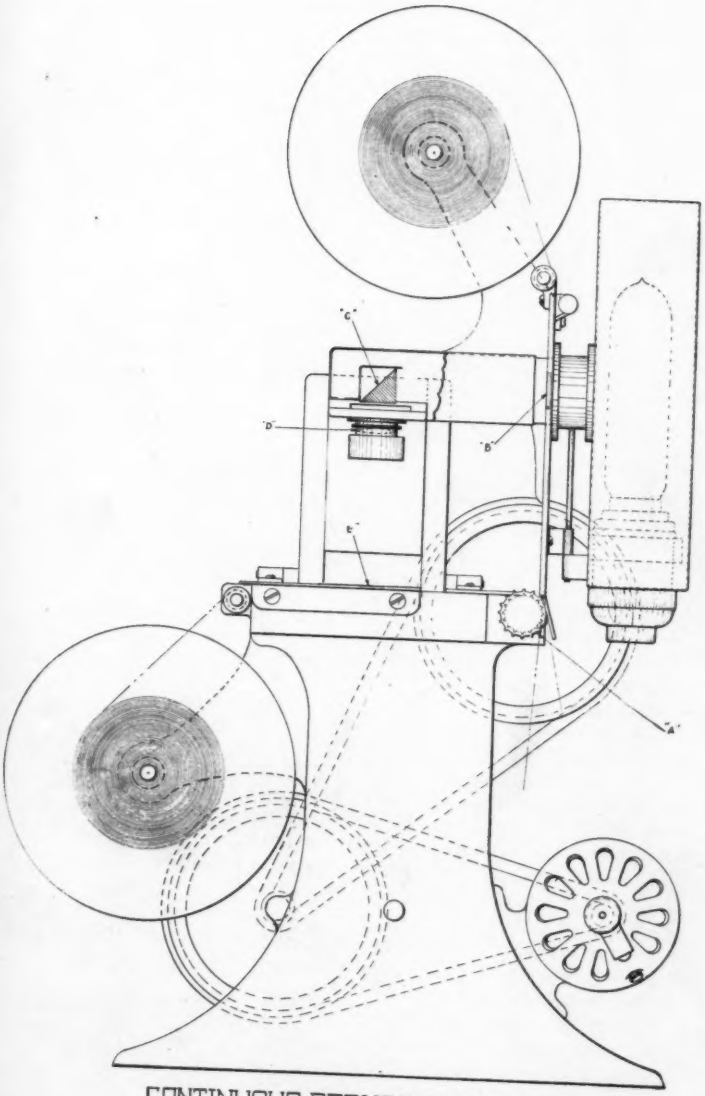
After several futile experiments, I reached this simple solution of my problem. Since the action of the lens, in reversing the image, necessitated the movement of the film strips in opposite directions, it must logically follow that a second reversal of the image on the positive would permit the travel of the two trips in the same direction.

To accomplish the second reversal of the image I used an internal reflecting prism. In addition to a second reversing of the image, this prism performs another essential service.

I will explain.

If you will refer to illustration you will note that the special sprocket (A) is provided with two sets of teeth.

The positive film travels over the small drum, between the teeth



CONTINUOUS REDUCTION PRINTER (VICTOR)

of the larger, which engage the negative strips. The teeth are cut on the same arbor, used for turning the sprocket itself.

Possibility of error is therefore reduced to the negligible quantity of imperfect arbors, machines or milling cutters.

Since the two strips are fed simultaneously and on the same shaft, they must necessarily advance at the exact speed ratio assigned to each.

However, I was confronted with the fact that this arrangement did not allow for the interpolation of a lens, if the two film strips were arranged parallel to each other.

The internal reflecting prism by deflecting the image 90 degrees permits this separation of the two film strips.

Again referring to the illustration. The aperture "B" permits illumination to penetrate the negative, forming an image on the positive at point "E," after passing through prism "C" and lens "D."

The result is exactly that which would be obtained if the two strips were placed in actual contact, with the desired reduction feature added.

The aperture "B" may be narrowed or widened to obtain the proper exposure.

An alternative method of governing the exposure may be gained by controlling the brilliancy of the light source.

The prism "C" is slightly rotatable, allowing for the correction of faulty camera frame lines. This feature is a distinct innovation in continuous printers; even contact printers do not possess this advantage.

Another advantage possessed by the Continuous Reduction Printer is the fact that no feed sprockets are required. The single sprocket smoothly and evenly unreels the material from the reel direct.

A variation of the apparatus described, introduces a geneva type of intermittent movement which I use in printing titles. In making titles the positive film is fed forward step by step, while a stationary negative at aperture "B" carries a single negative element which is duplicated the necessary number of times. A shutter is made to mask the light during the movement.

Needless to state, a negative film strip may be used in conjunction with this method and moved step by step with the positive. The apparatus thus becomes a new form of Step Printer.

Another variation of the Continuous Reduction Printer eliminates the reduction feature, applying the advantages of this type of printer to regular standard film.

In all its variations this apparatus is equipped with a suitable motor, with easily regulated speed control; although if desirable the machine may be operated by hand.

I believe the Continuous Reduction Printer is possessed of many new and desirable qualities, which the engineers of the industry will welcome; and it is a pleasure and an honor to first present it to the Society of Motion Picture Engineers.

STEREOSCOPIC MOTION PICTURES

C. FRANCIS JENKINS

Stereoscopic motion pictures, that is, motion pictures projected in such manner that the optence sees them in true simulation of all the wonderful depth, perspective and solidity of the real scene itself, has been the problem of photographers since Daguerre made his first twin "tintypes." Its practical solution has engaged the attention of the most brilliant minds, but remains unattained. By practical method I mean commercially useful, or profitable perhaps I should say. And this probably means stereoscopic vision without eye aids. It seems to be a much more difficult task than motion pictures in natural color.

Now that motion pictures have attained world-wide acceptance, the large financial return possible on the introduction of any new thing the public approves, warrants a correspondingly large appropriation for investigation and experimentation. For this reason it is believed that this problem will be taken up by motion-picture engineers sooner or later with sufficient financial backing to insure that persistent investigation which most nearly guarantees success.

It is likely, therefore, that a report of experiments made by the writer, covering a period of years, some of them original and some of them an effort to carry the work of others nearer the goal, may be worth recording.

Doubtless it will be conceded that stereoscopic picture projection will never be publicly acceptable, and therefore, profitable, until they are attained without requiring each individual of the audience to hold some sort of a device before his eyes. Better yet, the pictures should appear stereoscopically whether viewed with one or with two eyes.

Several different methods have been employed in attacking the problem. All those I shall describe in detail produce stereoscope motion pictures on the screen; and the results of some of the methods are really beautiful, and in some scenes, as, for example, looking at a forest across a wooded ravine, a true impression is obtained, which cannot be secured in any other way, and is very striking.

Perhaps one of the simplest methods, though not the best as to results, consists in projecting the separate picture frames of a film alternately through red and through green tinters, alternate frames having been made through right eye and left eye camera lenses, that is, left eye frames occur between right eye frames throughout the length of the film. The red and the green of both the filters and tinters must be complimentary and the composite screen picture must be viewed through corresponding red and green filters. These color filters may conveniently be glass or gelatine, and supported in spectacle frames, for example, although in 1898 a circular paper fan was used with two openings therein through which the eyes looked at the screen picture, these being covered

with colored gelatine. The cost of these fans was met by selling the advertising space thereon to a local merchant. These color filters before the eyes select the view for each eye, that is, they permit the right eye seeing only the right eye picture and the left eye seeing only the left eye picture, and a stereoscopic picture is the result. The picture is seen in stereoscopic relief, but only in monochrome, not in colors, as one might at first suppose. Both the filters and tinters may be any two tints; the right shades of red and green, red and blue, blue and yellow, or any others that are complimentary; that is, any two which laid over each other are no longer transparent.

Another method, somewhat similar, is to project with polarized light, all right eye film frames being projected with light polarized in a vertical plane, and all left eye frames with light polarized in a horizontal plane. The screen picture is then viewed through spectacles holding analyzers before the eyes, the right eye being in crossed relation to the left eye analyzer. This method has the same two objections as the first mentioned method, namely, (1) a 75 per cent. loss of light, and (2) requiring a viewing device.

A third method secures a 100 per cent. efficiency of light on the screen, but still has the objection of a viewing device. This consists of an opera glass through which the screen picture is viewed and having therein a reciprocating shutter, electrically actuated, to cut off the view of first one eye and then the other in synchronism with the alternate projection of the right eye and the left eye picture frames. This synchronism is obtained by electrically connecting the opera glass of each observer with a commutator on the sprocket shaft of the projecting machine. The pictures obtained are really very fine, especially if selected to bring out most effectively the striking value of plasticity and perspective.

Another method, somewhat similar, consists in projecting the pictures side by side on a double width screen, either alternately or simultaneously and viewing them through a pair of opera glasses (or plain tubes) having fitted in front of them suitable prisms for turning the eyes outwardly so that the left eye sees only the left picture and the right eye only the right screen picture. The projecting machine will be fitted with a device for alternately interposing in the path of light, perhaps before the projection lens, two prisms of, say, 10 degrees, with bases opposite, so that the right frame is projected onto the right screen, and the left frame the left screen. This presupposes the use of but a single standard film (as in the methods described earlier herein), the film carrying alternate stereoscopically-taken frames in single-line sequence; and fitting to the projector a prism-carrying device. Of course, two films or two rows of frames on a double width film can be used.

A somewhat newer method consists in projecting the stereoscopically made pictures through a vertical grating hanging a few inches in front of the screen. This grating was made of threads having, as near as could be obtained, a uniform diameter, from top

to bottom, and so spaced that the distance between adjacent threads was the same as the diameter of the thread. The right eye picture frames are all on one film and the left eye frames all on another film, the right eye film projected from a machine placed some distance to the right of an imaginary line drawn from the centre of and perpendicular to the surface of the screen, and the left eye film from a machine located on the left side of this line. The two machines superimpose their pictures and run synchronously. The grating has the effect of splitting up the projected picture from, say, the right machine into thin vertical slices or segments with a shadow (of the thread) lying between each adjacent picture segment. The left eye picture projected by the other machine is also cut up into vertical slices, each of which falls on the screen in the shadow of the string in the light of the right projector. The result is a composite picture consisting of alternate right eye and left eye vertical picture-segments, the segments entirely imperceptible to the observer. One may, therefore, view this screen picture from such an angular location that the right eye sees only the right eye vertical segment and the left eye only the left eye vertical segments, the picture as a whole in stereoscopic relief, and without any artificial aid, i. e., any device over the eyes. It is obvious that one may view the picture stereoscopically only from certain zones, the angle of the eyes from these zones being approximately the angle of projection of the two machines. So, again, we fall short of practical attainment.

But certain kinds of pictures can be obtained which appear stereoscopic to the unaided eyes, in fact appear so viewed with but a single eye. These are obtained by carrying the camera on a train, boat, automobile, or hand truck, the lens pointing at more or less of an angle to the line of travel of the camera-supporting vehicle. There is no doubt but that where appropriate this method puts interest in a picture which might otherwise be dull. In spite of the fact that pictures of this kind have been made for many years past, patents—both foreign and domestic—were issued thereon recently, which would seem to indicate that patent examiners don't go to the "movies."

A method devised some five years ago consisted in moving the background, and depth is fairly simulated, but roundness of nearby objects is purely mental delusion. We are prone to imagine solidity, shape, and other characteristics because, when we recognize the object, we recollect its form and unconsciously clothe it with its true mass contour. This is not true stereoscopy, and is valueless when applied to strange objects or scenes.

In the last two schemes mentioned just a plain ordinary motion-picture camera is sufficient, though it may be useful to some of you when you take up the problem to learn how the camera was constructed to secure right and left pictures of the same object in single line sequence on a single standard negative film. The most satisfactory form employed consisted of a standard type camera having

two right-angle prisms, one mounted (on the front of the box) on each side of the lens and so placed as to reflect across the camera front any view of object in front of the camera. Just in front of the lens and in axial line therewith, two smaller prisms were mounted, to reciprocate vertically, the travel being the thickness of one of the prisms. The prisms were crossed, and the reciprocating crank (run at half shutter speed) so timed that the prisms were alternately brought into position before the lens in time with the opening and closing of the shutter. Obviously such an arrangement reflects into the lens a view from first the right prism and then the left prism, so that the negative, when developed, carries alternately right and left eye frames.

The exact distance of the centres of the outside (stationary) prisms is a matter of no particular moment, though 3 inches is convenient and perhaps the best distance. To place them close together exaggerates the size of objects; placing them farther apart makes objects appear smaller, for the base line of the angle photographed is, in the mind when we look at the resultant picture, assumed to be the base line of the angle of vision, that is, the width between the pupils of the eyes.

Doubtless from this thought your mind has run ahead of me questioning, in anticipation, the effect of pictures made from base lines of 25, 50 and 100 feet when viewed in a stereoscope, and what practical application can possibly be made of it.

This question I will answer for you if I find sufficiently valuable pictures I am making from cameras located at the wing tips of a flying machine, and simultaneously exposed. It seems probable that these will be useful in conjunction with map-making cameras because it will give a relative idea of the heights, of known and unknown objects, and if further work proves the scheme has merit I shall be glad to lay the matter before you in detail, perhaps at our next meeting.